Electron Beam Projection Mask

BACKGROUND OF THE INVENTION

1. Field of the Invention

The Present invention relates to an electron beam projection mask, and particularly, to an electron beam projection mask (Electron-Beam exposure mask) for arranging a plurality of batch projection regions on a whole wafer surface.

2. Description of the Related Art

In recent years, in accordance with making high-density integrated circuit, an ultra-microfabrication technology is required for forming a semiconductor element and wiring which form an integrated circuit, and there is a demand for a development of technique for realizing it.

For example, in order to form a fine pattern having a line width of 0.1 μm or less, when a resist film is exposed, there is a technology using an electron beam for forming a fine patterning.

Since the electron beam has a very short wavelength as a matter-wave as compared with a wavelength used in other exposure technologies and its diffraction aberration is so small that it can be disregarded, the electron beam exposure

essentially has a high resolution. However, in electron beam exposure technique (EB direct drawing), since a pattern is drawn by a rectangle shape electron beam with a size of about several μm, a throughput is lowered. This method is called a variable-shaped electron beam exposure method.

In order to improve the throughput, at present, technology of a partial batch electron beam exposure (called a cell projection or block exposure.) is practically used. This partial batch electron beam exposure technology is described, for example, in Publication of Japanese Laid-Open patent.No.7-161605.

This partial batch electron beam exposure technology projects a pattern of several μm squire area at once which appears repeatedly in a device pattern by using a stencil type electron beam mask (called Si stencil mask, an aperture, a partial batch mask, a cell projection mask, or a block mask.) having at least one opening in Si film of about 20 μm of thickness. Accordingly, the number of shots of the electron beam is greatly reduced compared to the conventional EB direct drawing technology, and an improvement of throughput can be attained.

However, even if this partial batch electron beam exposure method is used, for a pattern without the repetition in patterns, the pattern must be directly drawn by the

electron beam of the rectangle shape with a size of about several μm squire(variable-shaped electron beam exposure method). For this reason, a further improvement in a throughput is required in mass-production.

The electron beam exposure method which aims at a high throughput compared to a partial batch electron beam exposure method is proposed in recent years. That is an electron beam reduction projection apparatus using a mask having a circuit pattern for a whole semiconductor chip, irradiates an electron beam at some region of the mask, thus the reduction pattern of the region passes a projection lens and forms an image of the pattern. Generally this technology is called an electron beam projection lithography (abbreviated as EPL). This EPL technology is described in Publication of Japanese Laid-Open patent No.2000-58446, for example.

Conventionally, the region which can be projected at once by the variable-shaped electron beam exposure method or partial batch exposure method was as small as 5-μm square. However, with the above-mentioned EPL technology, the region which can be projected at once is quite large with 250-micrometer square, and, thereby, the throughput is improved greatly.

A mask is used for above-mentioned partial batch electron beam exposure technology and EPL technology, however, the nonpermissible curvature or distortion of the mask arise

at the time of manufacturing of this mask and electron beam irradiation, and there is a problem that the position accuracy of a pattern deteriorates.

Fig. 4 shows the schematic figure of the conventional EPL (electron beam projection lithography) mask.

Generally, a pattern to be drawn has a pattern density which is not uniform and is out of balance in all over the mask or substrate. Here, for example, assuming that the pattern density of the region 41 (diagonal region) is high, and the pattern density of the region 42 (white region) is low, as shown in Fig. 4 (a), respectively.

Next, when the size of a batch projection region on a mask is 1mm , a drawing pattern is divided into the size of 1mm as shown in Fig. 4 (b).

Finally, when arranging 1mm size batch projection regions on an 8 inch silicon wafer 43, as usually shown in Fig. 4(c), they are arranged so that the move distance, i.e., the move time from a certain batch projection region to the next batch projection region to be projected may become short. Therefore, in many cases, each of the batch projection regions are arranged so that the adjacency relations of the original drawing pattern may not changed as much as possible.

Consequently, the imbalance of the pattern density will arise all over the 8 inch wafer, and according to this imbalance of pattern density, stress occurs at the time of

mask manufacturing and electron beam irradiation, thus curvature and distortion arise on a mask and a wafer. Accordingly, the position accuracy of a pattern worsen.

Since high projection accuracy is one of the important object of the EPL mask, curvature and distortion of the mask or wafer are problem.

As a technology relevant to this invention, there is a technology described in Publication of Japanese Laid-Open patent No. 7-66098.

However, in the conventional mask manufacturing method, there were problems that the imbalance of pattern density arose all over the wafer, the stress generated at the time of mask manufacturing and electron beam irradiation, the curvature and distortion of a wafer arose, and the position accuracy of a pattern deteriorated.

For example, a manufacturing method of the mask for X-ray steppers is described in Publication of Japanese Laid-Open patent No. 63-110634. In this publication, it is disclosed that since the X-ray stepper uses an X-ray absorbing material having same density for a pattern region and a cover region, shrink and curvature of the X-ray absorbing material by the stress is prevented.

This technology is effective to relieve the stress in a single batch projection region.

However, in this invention, in the case of the mask

with which a plurality of batch projection regions are arranged in manner of a matrix, an equalization of the pattern density on the whole wafer surface isn't realized. Rather, there is a possibility of enlarging imbalance of the pattern density on the whole wafer surface, and the stress concentrated on the specific region of the whole wafer surface cannot be prevented.

SUMMARY OF THE INVENTION

The electron beam projection mask of the present invention is characterized by arranging batch projection regions so that the pattern density may be equalized on the whole semiconductor substrate surface.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of an embodiment of the electron beam projection mask of the present invention;

Fig. 2 is a schematic view of an EPL (electron beam projection lithography) mask of an embodiment of the present invention;

Fig. 3 is a schematic view of an EPL mask of another embodiment of the present invention; and

Fig. 4 is a schematic view of a conventional EPL mask.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a schematic view of one embodiment of the electron beam projection mask according to a present invention.

In a present embodiment, when arranging the batch projection regions having a predetermined size in the manner of a matrix (12) on the 8 inch wafer 11 used as a semiconductor substrate, the patterns are arranged so that the pattern density may be equalized as much as possible on the whole wafer surface.

For example, the region 14 (diagonal region) where pattern density is high and the region 13 (white region) where pattern density is low are alternatively arranged like a checkered flag.

When they are arranged in this way, the imbalance of the pattern density on the whole 8 inch wafer surface decreases, thus a stress generated by the mask manufacturing and electron beam irradiation decreases. As a result, the curvature and distortion of a wafer become small, and degradation of the position accuracy of a pattern can be prevented.

The embodiment of this invention is hereafter explained in detail using a drawing.

Referring to Fig. 2, it shows the schematic figure of the EPL (electron beam projection lithography) mask as one embodiment of the present invention.

First, a pattern to be drawn has a pattern density which is not uniform and is out of balance all over the substrate, as shown in Fig. 2 (a).

Here, the region 21 (diagonal region) where pattern density is high and the region 22 (white region) where pattern density is low are distributed, as shown in Fig. 2 (a), respectively.

Next, if the size of the batch projection region on a mask is 1mm , a drawing pattern is divided into 1mm portions as shown in Fig. 2 (b).

Finally, when arranging the batch projection regions of 1mm on the 8 inch silicon wafer 23 as a semiconductor substrate, batch projection regions are arranged, for example, in the manner of a checkered flag so that pattern density may be equalized as much as possible on the whole wafer surface, as shown in Fig. 2 (c).

Thus, when the imbalance of the pattern density on the whole 8 inch wafer surface decreases, stress of the mask and substrate generated at the time of mask manufacturing and electron beam irradiation decreases, the curvature and distortion of a mask and wafer become small, and deterioration of the position accuracy of a pattern can be prevented.

Moreover, as shown in Fig. 3, pattern density can also be equalized by arranging the batch projection regions so

that the region 31 (diagonal region) where pattern density is high, and the region 32 (white region) where pattern density is low form a stripe shape, alternatively.

In the above-mentioned embodiment, although the present embodiment is utilized for EPL (electron beam projection lithography) mask, even if it is applied to the partial batch electron beam exposure mask, the same effect is acquired.

Here, the electron beam exposure mask is explained.

Conventionally, in the electron beam exposure method, the pattern is drawn in manner of single stroke, without using a mask at all. In this method, since the mask is not necessary, cost for the mask can be managed with zero. Moreover, there is an advantage of which does not need to re-create a mask to change some mask patterns suddenly.

However, the EB exposure method has a low throughput which prevents mass-production.

Recently, a mask is used for the electron beam exposure to improve the throughput. The mask used for the EB exposure method is roughly divided into a stencil type mask and a membrane type mask.

A stencil mask and its production method are described in, for example, Publication of Japanese Laid-Open patent No. 5-216216. The stencil mask has an opening portion(does not have a substance), electrons are pass through the opening portion, and in a portion without an opening, electrons are

scattered and does not pass through.

Usually, the opening pattern is formed by a method of dry etching which uses chemical gas to make a hole on the silicon wafer.

A stencil type mask is advantageous to earn an excellent contrast. An electron passes without being scattered since the opening portion does not have a substance, and at the portion without the opening has a predetermined thickness with silicon, almost all electrons can not pass (mere a few passes). However, since a pattern is formed by an opening, an inner pattern falls, so, a doughnut pattern etc. is not realizable.

On the other hand, the membrane type mask is described in Publication of Japanese Laid-Open patent No. 5-62888. The membrane type mask is made by forming an electron dispersion film on an electron penetration film, and pattern is formed by removing the electron dispersion film. The portion in which the electron dispersion film remains does not let an electron pass, but the portion in which an electron dispersion film does not exist (namely, portion in which only an electron penetration film exists) makes an electron penetrate.

However, even the electron penetration film is used, since some electrons are scattered, contrast is not so excellent as the stencil type mask. However, since the

electron dispersion film has arranged on the electron penetration film, a doughnut pattern can be formed.

Though this membrane type mask is developed for X-ray lithography, it is possible to use also for EB lithography, at present. That is, many of membrane type masks used for X-ray lithography can be used also for electron lithography. Fundamentally, the X-ray dispersion film scatters electrons, and an X-ray penetration film penetrates electrons. Generally, the mask is produced by using a silicon nitride film as an electron penetration film, and covered with heavy metals such as tungsten and chromium as an electron dispersion mask.

In addition, in the industry of EB lithography, the mask means the stencil type mask in many cases. Also the mask is called as an aperture or a reticle. It is because the mask having openings is advantageous in order to improve contrast.

However, in recent years, there is a technology of EPL which enables the batch exposure of the large area to realize the high throughput. This technology aims to carry out the batch exposure of the large area, and a doughnut pattern is also concerned, there is a movement which is going to apply the membrane type mask which can also form a doughnut pattern. If the stencil type mask of a doughnut pattern divided into two masks and perform the projection exposure with two masks,

a doughnut pattern can be formed.

According to this invention, as explained above, when the imbalance of the pattern density on the whole wafer surface decreases, stress generated at the time of mask manufacturing and electron beam irradiation decreases, the curvature and distortion of a wafer become small, thus deterioration of the position accuracy of a pattern can be prevented.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristic thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

The entire disclosure of Japanese Patent Application No. 2001-016085 (Filed on January 24th, 2001) including specification, claims, drawings and summary are incorporated herein by reference in its entirety.